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FYUG 3rd Semester

Course No.:CHM-SEC-201

Forensic Chemistry

[Unit-I: Instrumentation

Fundamental principles and forensic applications of thin layer chromatography, gas chromatography and liquid chromatography. Fundamental principles of Ultraviolet-visible spectroscopy, infrared spectroscopy, Colorimetric analysis and Lambert-Beer law.]

Forensic science is the use of scientific methods, chemical experiments, for solving crimes. Crime investigations depend on forensic science. Forensic science relays on chemistry and biochemistry to uncover the facts especially in crime scenes. Forensic chemistry can be seen as practical analytical chemistry, this as it deals with collecting samples and doing qualitative and quantitative analysis on them. Also, forensic chemistry deals with matching the results of the analyzed evidences with the suspected people in order to solve crimes and help the laws.

Importance of studying forensic chemistry: Why do we need to study it?

A chemist conduct qualitative and quantitative analysis on chemicals found on people, various objects and in solutions. A chemist analyze drugs, food, paints, fire debris, residues of gunshots, soil samples, remnants of explosives. This analysis is done to find biological toxins (biological weapons), toxic chemicals (chemical weapons) and radioactive substances (nuclear weapons).

Role of chemistry in solving crimes

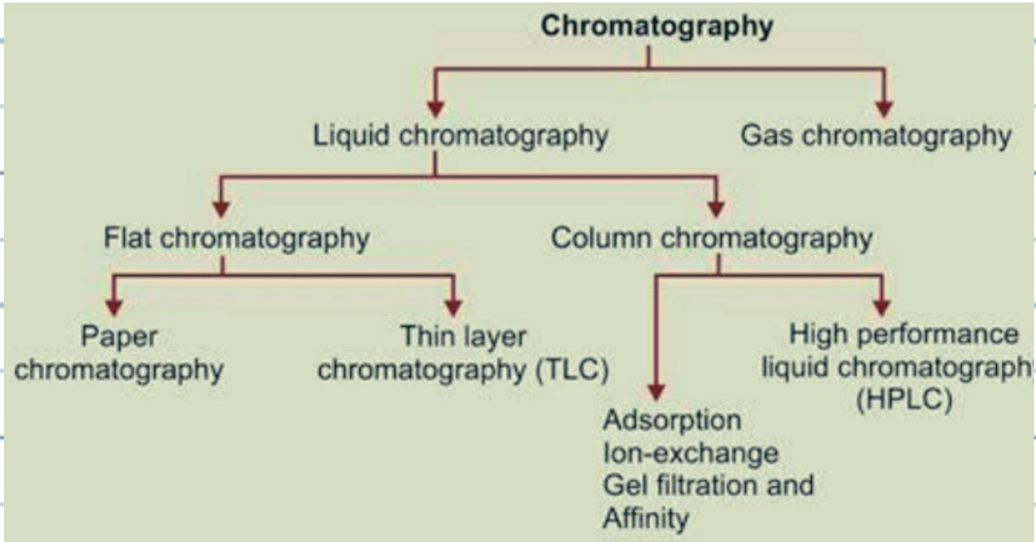
- Chemical science plays vital role in revealing crimes ambiguities, this is by performing qualitative and quantitative analysis on specimen obtained from crime scenes. Also, forensic chemistry encompasses arson investigation, toxicology and serology.
- Evidences collected from the crime scenes are analyzed for finding the source who/which caused the problem.

- Forensic chemist usually attend court sessions during trials to give their testimony as expert witnesses, this is to help the law establishing justice.
- A wide variety of instruments have been employed in the field of forensic chemistry, ranging from simple devices like density gradient column for the comparison of soil samples to sophisticated ones like mass spectroscopy and neutron activation analysis for qualitative and quantitative analysis of unknown samples. Other instruments are UV-Vis spectrophotometers, gas chromatography, atomic absorption spectroscopy and infrared spectroscopy.

Techiques used in forensic Chemistry

Chromatography

Chromatography is an important biophysical technique that enables the separation, identification, and purification of the components of a mixture for qualitative and quantitative analysis



All chromatographic techniques consist of a stationary phase and a mobile phase.

Stationary phase: This phase is always composed of a "solid" phase or "a layer of a liquid adsorbed on the surface a solid support".

Mobile phase: This phase is always composed of "liquid" or a "gaseous component."

Techniques used in forensic Chemistry

Chromatography

Chromatography is based on the principle where molecules in mixture applied onto the stationary phase (stable phase) is separating from each other while moving with the aid of a mobile phase. The factors effective on this separation process include molecular characteristics related to adsorption (liquid-solid), partition (liquid-solid), and affinity or differences among their molecular weights. Because of these differences, some components of the mixture stay longer in the stationary phase, and they move slowly in the chromatography system, while others pass rapidly into mobile phase, and leave the system faster.

Thin-layer chromatography

Thin Layer Chromatography (TLC) is an analytical technique in forensic science. It is a chromatography technique used to separate mixtures. Chromatography was discovered by M. Tswett in 1906. TLC is a type of liquid chromatography in which the stationary phase is in the form of a layer on a glass, an aluminum, or a plastic support. The term "planar chromatography" is often used for TLC. TLC is highly selective and flexible because of the great variety of layers of stationary phase.

PRINCIPLE OF THIN LAYER CHROMATOGRAPHY

Thin layer chromatography uses a thin glass plate coated with either aluminum oxide or silica gel as the solid phase. The mobile phase is a solvent chosen according to the properties of the components in the mixture to be analyzed. The principle of TLC is the distribution of a compound between a solid stationary phase (the thin layer) applied to a glass or plastic plate and a liquid mobile phase (eluting solvent) that is moving over the solid phase. A small amount of a compound or mixture is applied on the TLC plate just above the bottom of TLC plate. The plate is then developed in the developing chamber, containing solvent just below the level at which the sample was applied so that the spotted point do not dip in the solvent. The solvent start running through the particles on the plate

PRINCIPLE OF THIN LAYER CHROMATOGRAPHY

through the capillary action. As the solvent moves over the mixture, each compound will either remain with the solid phase or dissolve in the solvent and move in upward direction to the plate. Whether the compound moves up the plate or stays behind depends on the physical properties of that individual compound and thus depends on its molecular structure, especially functional groups. The solubility rule "Like Dissolves Like" is followed. The more similar the physical properties of the compound to the mobile phase, the longer it will stay in the mobile phase. The most soluble compounds will be carried out by the mobile phase farthest up the TLC plate. The compounds that are less soluble in the mobile phase and have a higher affinity to the particles on the TLC plate will stay behind.

Components of Thin Layer Chromatography (TLC)

TLC system components consists of:

TLC plates- These plates are preferably ready made with a stationary phase: These are stable and chemically inert plates, where a thin layer of stationary phase is applied on its whole surface layer. The stationary phase on the plates is of uniform thickness and is in a fine particle size.

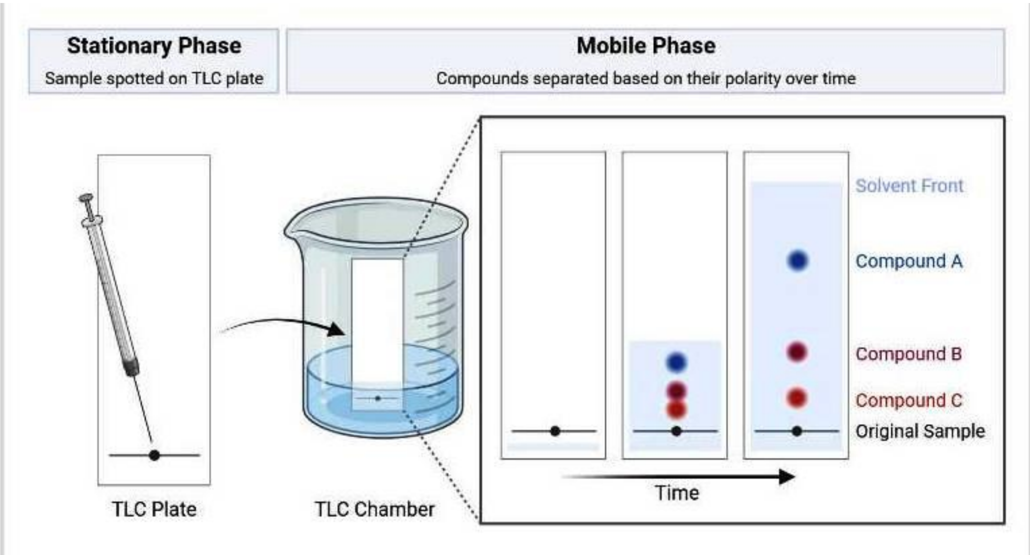
TLC chamber- This is used for the development of TLC plate. The chamber maintains a uniform environment inside for proper development of spots. It also prevents the evaporation of solvents, and keeps the process dust free.

Mobile phase- This comprises of a solvent or solvent mixture The mobile phase used should be particulate-free and of the highest purity for proper development of TLC spots. The solvents recommended are chemically inert with the sample, a stationary phase.

A filter paper- This is moistened in the mobile phase, to be placed inside the chamber. This helps develop a uniform rise in a mobile phase over the length of the stationary phase.

Procedure of Thin Layer Chromatography (TLC)

0. The stationary phase is applied onto the plate uniformly and then allowed to dry and stabilize. These days, however, ready-made plates are more commonly used.
0. With a pencil, a thin mark is made at the bottom of the plate to apply the sample spots.
0. Then, samples solutions are applied on the spots marked on the line in equal distances.
0. The mobile phase is poured into the TLC chamber to a leveled few centimeters above the chamber bottom.
0. A moistened filter paper in mobile phase is placed on the inner wall of the chamber to maintain equal humidity (and also thereby avoids edge effect).
0. Now, the plate prepared with sample spotting is placed in TLC chamber so that the side of the plate with the sample line is facing the mobile phase. Then the chamber is closed with a lid.
0. The plate is then immersed, such that the sample spots are well above the level of mobile phase (but not immersed in the solvent) for development.
0. Sufficient time is given for the development of spots. The plates are then removed and allowed to dry.
0. The sample spots are then seen in a suitable UV light chamber, or any other methods as recommended for the given sample.



Procedure of Thin Layer Chromatography (TLC)

Some common techniques for visualizing the results of a TLC plate include

- UV light
- Iodine Staining: is very useful in detecting carbohydrates since it turns black on contact with Iodine
- $KMnO_4$ stain: for organic molecules
- Ninhydrin Reagent: often used to detect amino acids and proteins

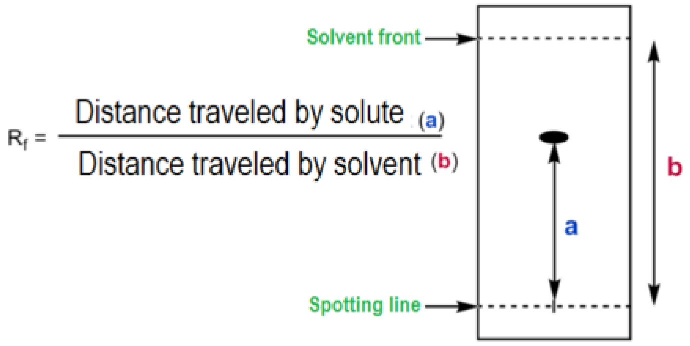
Retention Factor (R_f) Value

The behaviour of a compound on a TLC is usually described in terms of its relative mobility or R_f value. R_f or Retention factor is a unique value for each compound under the same conditiond.

The R_f for a compound is a constant from one experiment to the

next only if the chromatography conditions below are also constant:

- solvent system
- adsorbent
- thickness of the adsorbent
- amount of material spotted
- temperature



APPLICATIONS AS AN ANALYTICAL TECHNIQUE IN FORENSICS

- Identification of Drugs, Poisons and explosives
- Identification Of Dyes And Inks
- Identification of Pesticides

TLC has been applied virtually in all areas of analysis, including chemistry, biochemistry, biology, industrial, agricultural, environmental, food, pharmaceutical, clinical, natural products, toxicology, forensics, plant science, bacteriology, parasitology, and entomology.

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